Time-dependent neo-deterministic seismic hazard scenarios: ten years of prospective testing in Italy

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Current computational resources and physical knowledge of seismic waves generation and propagation processes allow nowadays for viable numerical and analytical modelling of earthquake ground shaking. Accordingly, a scenario-based neo-deterministic approach (NDSHA) to seismic hazard assessment has been proposed, which permits considering a wide range of possible seismic sources as the starting point for deriving scenarios by means of full waveforms modeling. The method does not make use of attenuation relations and naturally supplies realistic time series of ground shaking, including reliable estimates of ground displacement, readily applicable to complete engineering analysis.

Based on NDSHA, an operational integrated procedure for seismic hazard assessment has been developed that allows for the definition of time-dependent scenarios of ground shaking, through the routine updating of formally defined earthquake predictions. The integrated NDSHA procedure for seismic input definition combines different algorithms for the space-time identification of strong earthquakes, which make use of general concepts of pattern recognition to deal with multiple sets of seismic precursors, with methods for the realistic modeling of ground motion. Accordingly, a set of neo-deterministic scenarios of ground motion at bedrock, which refers to the time interval when a strong event is likely to occur within the alerted area, can be defined by means of full waveform modeling, both at regional and local scale.

The space and time constraints about the impending strong earthquakes are provided by two formally defined and globally tested algorithms for intermediate-term middle-range earthquake prediction, namely CN and M8S (i.e. a spatially stabilized variant of M8). Italy represents the only region of moderate seismic activity where the two algorithms are applied simultaneously for the routine monitoring of seismicity and several experiments have been dedicated to assess the robustness of the methodology against the unavoidable uncertainties and possible changes in the input data. With these results acquired, an experiment has been launched in July 2003, aimed at prospective testing of CN and M8S predictions in the Italian region and its surroundings. Predictions are regularly updated every two months and are made accessible to a number of scientists (a complete archive of predictions is available on-line); the results obtained during about ten years of rigorous prospective testing already permitted a preliminary assessment of the issued predictions.

The time-dependent neo-deterministic ground motion scenarios associated with CN and M8S alarmed areas, are regularly updated every two months since 2006. The routine application of the time-dependent NDSHA approach provides information that can be useful in assigning priorities for timely mitigation actions and, at the same time, allows for a rigorous prospective testing and validation of the proposed methodology. As an example, for sites where ground shaking values greater than 0.2 g are estimated at bedrock, further investigations can be performed taking into account the local soil conditions, to assess the performances of relevant structures, such as historical and strategic buildings.

The issues related with prospective testing and validation of the time-dependent NDSHA scenarios will be discussed, illustrating the results obtained for the recent strong earthquakes in Italy.